

FORM PTO-1390 (Modified) (REV 11-98)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 14989.260	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371				U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/743738	
				PRIORITY DATE CLAIMED 30/07/98	
INTERNATIONAL APPLICATION NO. PCT/DE99/01691		INTERNATIONAL FILING DATE 05/06/99			
TITLE OF INVENTION MECHANICAL CONNECTING ELEMENT					
APPLICANT(S) FOR DO/EO/US Hans Nusskern, Viktor Dahm					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:					
<ol style="list-style-type: none"> 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1). 4. <input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date. 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371 (c) (2)) <ol style="list-style-type: none"> a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input checked="" type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)). 7. <input checked="" type="checkbox"/> A copy of the International Search Report (PCT/ISA/210). 8. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3)) <ol style="list-style-type: none"> a. <input checked="" type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 9. <input checked="" type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 10. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)). 11. <input checked="" type="checkbox"/> A copy of the International Preliminary Examination Report (PCT/IPEA/409). 12. <input checked="" type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)). 					
<p>Items 13 to 20 below concern document(s) or information included:</p> <ol style="list-style-type: none"> 13. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 14. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 15. <input type="checkbox"/> A FIRST preliminary amendment. 16. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 17. <input type="checkbox"/> A substitute specification. 18. <input type="checkbox"/> A change of power of attorney and/or address letter. 19. <input checked="" type="checkbox"/> Certificate of Mailing by Express Mail 20. <input checked="" type="checkbox"/> Other items or information: 					
<p>Application Data Sheet</p>					

09/743738

PCT/DE99/01691

14989.260

21. The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

- ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1,000.00
- ☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00
- ☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =

\$860.00

Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)). ☐ 20 ☐ 30

\$0.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	34 - 20 =	14	x \$18.00	\$252.00
Independent claims	1 - 3 =	0	x \$80.00	\$0.00
Multiple Dependent Claims (check if applicable).			<input checked="" type="checkbox"/>	\$270.00

TOTAL OF ABOVE CALCULATIONS = \$1,382.00

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable). ☐

\$0.00

SUBTOTAL = \$1,382.00

Processing fee of \$130.00 for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)). ☐ 20 ☐ 30

\$0.00

TOTAL NATIONAL FEE = \$1,382.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). ☐

\$0.00

TOTAL FEES ENCLOSED = \$1,382.00

Amount to be refunded	\$
charged	\$

- ☐ A check in the amount of _____ to cover the above fees is enclosed.
- ☒ Please charge my Deposit Account No. **03-1240** in the amount of **\$1,256.00** to cover the above fees.
A duplicate copy of this sheet is enclosed.
- ☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **03-1240** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Ira J. Schaefer, Esq.
Chadbourne & Parke LLP
30 Rockefeller Plaza
New York, NY 10112

212-408-1075

SIGNATURE

Ira J. Schaefer

NAME

26,802

REGISTRATION NUMBER

1/16/01

DATE

09/743738

CERTIFICATE OF MAILING BY "EXPRESS MAIL" (37 CFR 1.10)Applicant(s): **Hans Nusskern, Viktor Dahm**

Docket No.

14989.260

Serial No.

To Be Assigned

Filing Date

January 12, 2001

Examiner

N/A

Group Art Unit

N/A

Invention: **MECHANICAL CONNECTING ELEMENT**I hereby certify that this **Application Filing Under 35 USC 371**

(Identify type of correspondence)

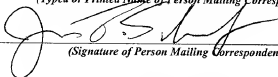
is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under
 37 CFR 1.10 in an envelope addressed to: The Assistant Commissioner for Patents, Washington, D.C. 20231 on

1/16/01

(Date)

Ira J. Schaefer

(Typed or Printed Name of Person Mailing Correspondence)



(Signature of Person Mailing Correspondence)

EK069165171US

("Express Mail" Mailing Label Number)

Note: Each paper must have its own certificate of mailing.

11/PETS

09/743738

JC07 Rec'd PCT/PTO 16 JAN 2001

PCT/DE99/01691
English translation
ERG 102/0Q/US

5

Applicant: G. Rau GmbH & Co.
Pforzheim, DE

10

Mechanical connecting element

- 15 The invention relates to a connecting element for mechanically connecting constructive elements. It comprises an elastically deformable tensioning element which applies a holding force in its elastically deformed state, onto at least one constructive element connected by the
- 20 connecting element, thus generating a nonpositive connection of at least one constructive element with the tensioning element or with another constructive element. In particular, the invention relates to the linking of longitudinal, wire-shaped constructive elements as e.g. profiles and tubes, also with small diameters in the range
- 25 of a few millimeters or less. A connection is to be understood as the joint of a tensioning element to a constructive element to be connected, or the connection of two or more constructive elements to each other. In particular, the invention relates to the mechanical connection of constructive elements consisting of a material which is difficult to weld or to solder, e.g. a nickel-titanium alloy.
- 30

09743738-01-1601

In many ranges of technology, there is the requirement to connect constructive elements mechanically, however, connections which allow to be detached if necessary, are desired, too. A usual method is to use an elastically deformable tensioning element which applies a holding force in its elastically deformed state, onto one constructive element to be connected, thus generating a nonpositive connection of at least one constructive element with the tensioning element or with another constructive element. Principally, there are two ways of deforming the tensioning element elastically.

The first variant is to bring the tensioning element from a relaxed initial position into a pre-tensioned position by means of an elastic deformation, where it is deformed and elastically expanded. In the pre-tensioned position, the constructive element to be connected (at least one) can be inserted into the tensioning element (or, if necessary, vice versa, the tensioning element into the constructive element). After that, the tensioning element is allowed to return to a less tensioned position, where it applies a holding force, caused by the elastic deformation, onto the connected constructive element. This holding force generates the nonpositive connection.

The second possibility is to bring the tensioning element from its relaxed initial position into a tensioned position, where the mechanical tension generated by the expansion causes the holding force. The tensioning element can be pre-tensioned in an opposite direction before the insertion of the constructive element to be connected, if necessary.

Thus, as to the state of the art, it is known to fit coil springs made of steel to the ends of Allan keys; these

coil springs are wound around the tip of the key in a way that the coil spring fixes the key in a non-positive way due to the spring load. With this, the key can be fixed to a bunch of keys by means of the coil spring. According to the first described variant, the coil spring is expanded for inserting the Allen key, and generates the holding force in a partially relaxed position. On the other hand, the coil spring can also be applied to the key by the second described variant, being contracted and decreasing the diameter, which presents similarities with crimping; this, too, generates a holding force by the winding around the key end.

Another known example from the state of the art are shrinking joint sleeves for the butt joining of tubes, e.g. according to the literature reference Engineering Aspects of Shape Memory Alloys, Duerig, Melton, Stöckel, Wayman, Verlag Butterworth-Heinemann Ltd., 1990 or according to DE 4026644 C1. Here, a shape memory alloy in form of a sleeve, with a suppressed shape memory effect, is located around the joint and shrunk. The entire usable shrinking effect amounts to approximately three to four percent after subtracting the installation tolerance, the substrate tolerance, the substrate deformation during shrinking and the suppressed shape memory effect; this makes it necessary to comply exactly with the tolerances in order to generate a reliable joint. These shrunk joints are based on a one-way effect, this means that the joints cannot be detached any more. The effect applied for joining during the shrinking process is based on a phase transformation, during which the metallographic structure of the shrinking sleeve changes.

Taking into account this state of the art, the invention relates to the creation of a connecting element for me-

09743736-011601

chanically connecting constructive elements, which allows bigger tolerances and dimensional deviations for the tensioning element and/or the constructive elements, but at the same time creates a high holding force. The strength of the connection and the generated holding force must be high. Furthermore, it is desirable to detach the realized connection if necessary.

The solution according to the invention, for a connecting element for mechanically connecting constructive elements, comprising an elastically deformable tensioning element which applies a holding force in its elastically deformed state, onto at least one constructive element connected by the connecting element, thus generating a nonpositive connection of at least one constructive element with the tensioning element or with another constructive element, consists of the fact that the tensioning element comprises a spring material made of a superelastic shape memory alloy, in particular a nickel-titanium alloy, which is expanded elastically (purely elastically, superelastically) in the tensioning element.

For alloys containing a similar amount of titanium and nickel atoms, particular effects can be observed. Due to these effects, such alloys are also designated shape memory alloys. These effects are based on a thermoelastic martensitic phase transformation, i.e. a temperature-dependant modification of the crystalline structure: at high temperatures, the alloy is austenitic, at low temperature, however, it is martensitic. According to T. W. Duerig and H. R. Pelton, ("TI-NI Shape Memory Alloys", in: Materials Properties Handbook: Titanium Alloys, 1994, pages 1035-1048, ASM International 1994), two characteristics have to be distinguished for shape memory alloys. Alloys with a titanium content between 49,7 to

50,7 atom% show a thermal shape memory, also designated shape memory; whereas alloys with a titanium content of 49,0 to 49,4 atom% show a mechanical shape memory, also designated superelasticity. Not only binary nickel-
 5 titanium alloys can have the stated properties. A shape memory alloy can contain ternary ingredients (e.g. iron, chrome or aluminum). The relation of nickel and titanium, as well as the existence of ternary ingredients, have big influence on the intensity of the thermal and mechanical
 10 shape memory.

In order to use the thermal shape memory for constructive elements as e.g. the shrinking sleeves described above, an alloy with adequate composition is converted
 15 diffusionlessly from the austenitic crystalline structure to the martensitic crystalline structure by cooling down. A subsequent deformation of a constructive element made of this alloy can be reversed by a thermal treatment of that constructive element (heating to a temperature above
 20 a certain conversion temperature). This recovers the initial austenitic crystalline structure and the constructive element returns to its original shape. The conversion temperature is generally understood as the temperature at which the martensite has completely converted to
 25 austenite. The conversion temperature strongly depends on the composition of the alloy and on the internal tensions of the constructive element. Constructive elements which have a thermal shape memory can perform movements and/or apply forces.

30

For a constructive element with austenitic crystalline structure, the mechanical shape memory effect appears when the constructive element is deformed in a certain temperature range. For this, it is energetically more
 35 favorable for the austenitic crystalline structure, to

convert to martensite in a tension-induced way, whereby elastic expansions of up to 10% can be obtained. When unloaded, the crystalline structure returns to the austenitic phase. Therefore, constructive elements made of such alloys are used for the storage of deformation energy.

Alloys showing the characteristics described above are known by the designations of Nickel-Titanium, Titanium-Nickel, Tee-nee, Memorite^R, Nitinol, Tinel^R, Flexon^R, Euroflex^R and Shape Memory Alloys. These terms do not refer to a single alloy with a certain composition, but to a family of alloys showing the described characteristics.

Due to the particular properties of nickel-titanium alloys, there is a high interest in many fields of technology, e.g. medical engineering and precision mechanics, in the application of constructive elements made of shape memory alloys, also in form of tubes, in particular with small outer diameter. In mechanics, they can e.g. be used for switching elements, setting elements or valves. In medical engineering, too, shape memory alloys are increasingly applied, as constructive elements made of such alloys are bio-compatible and fatigue-resistant, and because they show high buckling resistance in case of superelastic alloys. Examples for the application of nickel-titanium alloys in medical engineering are guidance wires for catheters, vessel supports (stents), as well as endoscopic and laparoscopic instruments for the minimal invasive diagnosis and therapy.

The special characteristic of superelastic shape memory alloys, consisting in achieving elastic expansions of up to ten percent, thus significantly higher than for spring materials made of steel or bronze, is applied in the scope of the invention, in order to use tensioning ele-

ments which are elastically expanded, made of such spring material. As the elastic expansion range is ten times higher as compared to a spring steel, the tolerances of invention-related tensioning elements can be bigger di-
5 mensioned.

The usable effect of the invention-related tensioning element is increased by the factor of three approxi-
mately, as compared to a shrinking sleeve made of a shape
10 memory alloy as described above. During installation, such a shrinking sleeve is in martensitic state and converts to austenitic state when heated. The shrinking sleeve tries to restore the initial, smaller shape, thus generating the holding force.

15 The tensioning element according to the invention is in austenitic state already at the start of the installation and converts to the tension-induced, martensitic state during the elastic tensioning or expanding, respectively.
20 Due to the geometric shape of the tensioning element, the usable effect can be increased by the factor three approximately, as compared to the known shrinking sleeve. In general, for an invention-related tensioning element, no elongation effects, i.e. shrinking effects, occur for
25 the generation of the cohesive force, but merely bending forces or shear forces.

The following embodiments of the invention show further advantageous features and specialties; these are further
30 described and explained with the schematic representation in the drawings, as follows.

- Fig. 1 shows a tensioning element according to the invention in form of a compression spring.
35 Fig. 2 shows a compression spring during assembly.

- Fig. 3 shows a connecting element according to the invention with a compression spring.
- Fig. 4 shows a tensioning element according to the invention in form of a tension spring.
- 5 Fig. 5 shows a tension spring during assembly.
- Fig. 6 shows a connecting element according to the invention with a tension spring.
- Fig. 7 shows a connecting element according to the invention with a spring and a joint element.
- 10 Fig. 8 shows a tensioning element according to the invention in form of a leg spring.
- Fig. 9 shows a leg spring during assembly.
- Fig. 10 shows a first connecting element according to the invention with a leg spring.
- 15 Fig. 11 shows a second connecting element according to the invention with a leg spring.
- Fig. 12 shows a first connecting element according to the invention in form of a clamping sleeve.
- Fig. 13 shows a pre-tensioned clamping sleeve as to Fig. 12.
- 20 Fig. 14 shows a cross section of a first connecting element according to the invention with a clamping sleeve.
- Fig. 15 shows a longitudinal section as to Fig. 14.
- 25 Fig. 16 shows a first invention-related connecting element with leg spring and clamping sleeve.
- Fig. 17 shows a second connecting element according to the invention with leg spring and clamping sleeve.
- 30 Fig. 18 shows a second connecting element according to the invention in form of a clamping sleeve.
- Fig. 19 shows a pre-tensioned clamping sleeve as to Fig. 18.

- Fig. 20 shows a cross section of a second connecting element according to the invention element with a clamping sleeve.
- Fig. 21 shows a longitudinal section as to Fig. 20.
- 5 Fig. 22 shows a third connecting element according to the invention in form of a clamping sleeve,
- Fig. 23 shows a pre-tensioned clamping sleeve as to Fig. 22.
- Fig. 24 shows a cross section of a third connecting element according to the invention with a clamping sleeve,
- 10 Fig. 25 shows a longitudinal section as to Fig. 24.
- Fig. 26 shows a fourth connecting element according to the invention in form of a clamping sleeve.
- 15 Fig. 27 shows a pre-tensioned clamping sleeve as to Fig. 27.
- Fig. 28 shows a cross section of a fourth connecting element according to the invention with a clamping sleeve.
- 20 Fig. 29 shows a longitudinal section as to Fig. 28.
- Fig. 30 shows a fifth connecting element according to the invention in form of a clamping sleeve.
- Fig. 31 shows a pre-tensioned clamping sleeve as to Fig. 30.
- 25 Fig. 32 shows a cross section of a fifth connecting element according to the invention with a clamping sleeve.
- Fig. 33 shows a longitudinal section as to Fig. 32.
- 30 Figures 1 - 6 show lateral views of connecting elements according to the invention, the tensioning element of which comprises a helicoidal spring 1, 4, 7, into which is inserted, in axial direction, at least one constructive element 2 to be connected. For this, the spring can
- 35 be elastically deformed and pre-tensioned for inserting

at least one constructive element into it, being partially relaxed for realizing the connection, or the spring will be tensioned in order to realize the connection. Furthermore it may be necessary to turn open the
 5 coil of the spring for increasing the diameter of the coil when inserting the mentioned at least one constructive element.

In figures 1 - 3, the tensioning element is a compression
 10 spring 1. In Fig. 1, it is illustrated in relaxed state. It consists of a shape memory alloy with superelastic characteristics. In order to connect two or more wire-shaped constructive elements 2, 3 at their face ends, the compression spring 1 will be compressed in axial direc-
 15 tion and pre-tensioned when inserting the constructive elements 2, 3. This increases the diameter of the spring, so the parts to be connected can be inserted as shown in Fig. 2. The constructive elements 2, 3 are pressed together at their face ends; this is not illustrated in the
 20 figures for reasons of clearness.

After that, the compression spring is partially relaxed as illustrated in Fig. 3, whereby it expands again in longitudinal direction, trying to reach its initial,
 25 smaller diameter. This is inhibited, as the diameter of the constructive elements 2, 3 to be connected is bigger than the initial internal diameter of the spring which it now aims to restore. This partial relaxation causes a contact pressure of the compression spring 1 onto the
 30 constructive elements 2, 3, with the compression spring now in tight contact to the constructive elements 2, 3 to be connected, generating the desired holding forces of the joint connection. The constructive elements 2, 3 to be connected at their front ends, are drawn with a gap in
 35 Fig. 3, for better presentability. For detaching the con-

nection, the pressure spring 1 can once again be pressed into a shape according to Fig. 2, thus enabling to pull out the constructive elements 2, 3.

5 Figures 4 - 6 show a connection of two constructive elements 2, 3, realized by a tension spring 4, shown in Fig. 4 in relaxed state, made of a superelastic shape memory material. The tension spring is preferably wound to a block, i.e. winding next to winding. For inserting the
10 two or more constructive elements 2, 3, the windings are opened a little, so that the diameter of the windings becomes a little bigger, and stretched in axial direction at the same time. The constructive elements 2, 3 will be pushed together with their face ends, not shown in Fig. 5
15 for a better presentability, and the tension spring 4 will be partially relaxed. Then, it adapts a state according to Fig. 6, where its diameter as well as its length are increased as compared to the initial state illustrated in Fig. 4, and decreased as compared with the
20 state according to Fig. 5. This generates a contact pressure onto the inserted constructive elements 2, 3, causing the desired holding forces of the joint connection.

Fig. 7 illustrates a cross section through a connecting
25 element according to the invention with a spring, which can be a compression spring 1, a tension spring 4, or a leg spring 7, described further below. Two or more constructive elements 2, 3 are inserted into the spring, with their face ends joined, being connected to each
30 other by the spring. The two constructive elements 2, 3 contact each other with their face ends in the range of the spring 1, 4, 7, or are oriented to each other with their face ends. The constructive elements 2, 3 are preferably rod-shaped or tube-shaped and preferably have a
35 circular cross section. However, other cross sections,

e.g. rectangular or square cross sections, are possible, too.

Alternatively, it is possible that the spring 1, 4, 7 is not wound around two constructive elements 2, 3 joined together, but around a core consisting of one piece, so that only one constructive element to be connected is inserted into the spring. The inserted constructive element can then be connected to another element by means of the spring, e.g. with one leg of the spring.

Another advantageous feature shown in Fig. 7 can consist in the fact that the two or more constructive elements 2, 3 are surrounded, in the range of their contact point, by a joint element, e.g. a joint tube 5 with thin walls or various joint shells, transferring the holding force of the spring to the constructive elements 2, 3 to be connected.

If the surfaces of the constructive elements 2, 3 to be connected, or those of a single-piece core, respectively, are very smooth, it can be advantageous to increase the holding forces by increasing the friction of a section 6 of at least one constructive element to be connected and inserted into the spring, being engaged with the tensioning element, i.e., the spring, by e.g. raising, structuring or coating. In special designs, it may occur that two or more constructive elements 2, 3 to be connected, are arranged parallel to each other within a section 6 of the spring.

Figures 8 - 11 show embodiments of connecting elements according to the invention, the tensioning element of which being a leg spring 7 shown relaxed in Fig. 8, with two legs 8, 9, consisting of a superelastic shape memory

alloy. It can be used in a way similar to the compression springs 1 and tension springs 4 described above, whereas the particularities further explained as to Fig. 7, e.g. one-piece cores, joint elements and friction-increasing sections are possible here, too.

According to a first variant illustrated in figures 9 and 10, the legs 8, 9 of the leg spring 7 are bent up during the insertion of at least one of the constructive elements 2, 3, in order to increase the diameter of its windings and for pre-tensioning of the leg spring 7 against the direction of winding of the leg spring 7. The legs 8, 9 of the leg spring 7 then are transposed to each other by a certain transposition angle. After inserting the constructive elements 2, 3 to be connected into the leg spring 7, the leg spring 7 is partially relaxed for realizing the connection; it adopts a state according to Fig. 10. By this, the diameter of its coils decreases and the desired holding force onto the inserted constructive elements 2, 3 is obtained.

As an alternative, it is also possible, starting from the relaxed state of the leg spring 7 according to Fig. 8, or starting from the pre-tensioned state of the leg spring 7 according to Fig. 9, to bend together in winding direction of the leg spring, exceeding the relaxed state, the legs 8, 9 of the leg spring 7, after the insertion of the constructive elements 2, 3 to be connected, for a decrease of the diameter of its windings, to obtain the connection. By this, the leg spring 7 is tensioned and decreases its pitch, which can be set forth until block formation, and decreases its diameter.

The diameter decrease is partially inhibited, however, by the inserted constructive elements 2, 3, as soon as the

inner diameter of the leg spring 7 comes in contact with the parts to be connected. This produces a contact pressure which obtains the desired holding forces of the joint connection. According as the leg spring 7 is or is not bent up in an intermediate step according to Fig. 9, constructive elements 2, 3 with a diameter bigger or smaller than the winding diameter, can be inserted into the leg spring 7.

For the variant illustrated in Fig. 11, the constructive elements 2, 3, the diameter of which is smaller than the leg spring 7, are inserted in an initial position according to figure 8, and the legs 8, 9 are bent together in winding direction of the spring. Preferably, the legs 8, 9 are bent together until they reach a parallel orientation. This makes it easier to fix the legs 8, 9 with respect to each other, thus assuring the maintenance of the spring tension.

For this, the legs 8, 9 can be located, e.g. side by side, and fixed with a section of a spring tube, pushed over the leg ends 8, 9, preferably consisting of a superelastic shape memory material, thus corresponding to a clamping sleeve 10, described hereafter. At the same time, one or more further pieces can be introduced and also joined into the other end of the sleeve, fixing the tensioned legs 8, 9 of the leg spring 7.

Figures 12 - 15 illustrate a first connecting element according to the invention which comprises a tensioning sleeve 10 made of a superelastic shape memory material as connecting element. Fig. 12 illustrates a cross section through the clamping sleeve 10. In its relaxed state, it preferably shows a circular cross section; in the pre-tensioned state according to Fig. 13, and in the par-

tially relaxed state according to Fig. 14, it presents an oval cross section.

For the insertion, in axial direction, of the constructive elements 2, 3 to be connected, into the clamping sleeve 10, it is necessary to bring the clamping sleeve 10 from the position illustrated in Fig 12, to the oval form according to figure 13, by compressing it. Hereby, the clamping sleeve 10 is elastically deformed and pre-tensioned. In this state, both constructive elements 2, 3 to be connected are inserted, according to the cross section in Fig. 14; after that, the clamping sleeve 10 is relaxed.

The unloading partially relaxes the clamping sleeve 10; it aspires to recover its initial, round state. This, however, is partially impeded, as the inserted constructive elements 2, 3 together have a dimension that is bigger than the initial inner diameter of the clamping sleeve 10. This generates a force pressing together the constructive elements 2, 3 to be connected, joining them reliably. For detaching the connection, the clamping sleeve 10 can once again be pressed into a shape according to Fig. 13, bringing it into a pre-tensioned state, enabling to pull out the constructive elements 2, 3.

As compared to a conventional spring steel or a spring bronze, which allow a maximum elastic expansion of 0.5%, the clamping sleeve 10 according to the invention, consisting of a superelastic shape memory, offers the advantage to allow up to 8% or more of elastic expansion. Thus, it is possible to allow bigger tolerances, whereas, e.g., half of the usable expansion range can be applied for the manufacturing tolerances and the other half can

be applied for the maintenance of the elastic deformation and the generation of the holding forces.

Also as compared to the known shrinking sleeves consisting of shape memory alloys, used for shrinking connections, the clamping sleeves 10 according to the invention offer essential advantages, as they allow bigger tolerances and dimensional deviations without affecting the function. For example, a pre-expanded shrinking sleeve of an inner diameter of 0.80 mm, can be shrunk to an inner diameter of 0.76 mm as a maximum. On the other hand, a round, superelastic tube section of a clamping sleeve 10 with an inner diameter of 0.80 mm can be compressed to an inner diameter of 0.47 mm without a permanent deformation of the pre-tensioned tube. The holding forces for this are generated by elastic deformations, bending forces and expansions.

In the embodiment according to the figures 12 - 14, the outer diameter of the clamping sleeve 10 in its initial state is 1.00 mm according to Fig. 12, and the inner diameter is 0.82 mm. In the pre-tensioned state according to Fig. 13, the large outer diameter is 1.62 mm, the large inner diameter is 1.44 mm, the small outer diameter is 0.64 mm and the small inner diameter is 0.46 mm. The diameter of the two constructive elements 2, 3 is 0.45 mm each, so that the clamping sleeve 10 according to Fig. 14, shows following dimensions in the partially relaxed state: large outer diameter 1.10 mm, large inner diameter 0.92 mm, small outer diameter 0.90 mm and small inner diameter 0.72 mm.

Fig. 15 illustrates a section A - A' according to Fig. 14. The section B - B' corresponds to the representation in Fig. 14. It can be seen that the constructive elements

2, 3 to be connected, are inserted into the tube-shaped clamping sleeve 10; the constructive elements are arranged parallel to each other in a section of clamping sleeve 10. As an alternative, more than two constructive elements to be connected, can be inserted into the clamping sleeve 10. Furthermore, embodiments are possible, in which two or more constructive elements 2, 3 to be connected, are inserted, which contact each other with their face ends in the clamping sleeve 10, or which are oriented with their ends facing to each other.

The respective ends of the connected constructive elements 2, 3 can be inside of the clamping sleeve 10, as shown in Fig. 15, or stick out of the clamping sleeve 10. The holding force generated by the clamping sleeve 10 is determined by the mechanical material properties, the dimensions, the geometric conditions and the surface structure. If the clamping sleeve 10 has a corresponding length, it can achieve a tensile strength of the connection which is higher than that of the connected constructive elements 2, 3.

Fig. 16 illustrates a connecting element fulfilling the function of a T-junction. A leg spring 7 is wound around a constructive element 2; the legs 8, 9 of the leg spring 7 are fixed with a clamping sleeve 10. This procedure generates a fixed connection of the leg spring 7 and the constructive element 2. A further constructive element 3 is inserted in the clamping sleeve 10, and fixed together with the legs 8, 9. It is held, together with the legs 8, 9, by the clamping sleeve 10 by means of elastic deformation forces.

In Fig. 17, a leg spring 7 is wound around a constructive element 2 and connected to it, e.g., as described in fig-

ures 10 and 11. One of the legs 8 is connected to a further constructive element 3 with a clamping sleeve 10; the other leg 9 is connected to a further constructive element 3a with a clamping sleeve 10a. By this, it is possible to generate cross junctions.

Figures 18 - 21 correspond to the figures 12 - 15 and show a second connecting element according to the invention, featuring a clamping sleeve 10 with two or more constructive elements 2, 3 to be connected, inserted; these constructive elements can contact each other with their face ends in the clamping sleeve 10, or are oriented with their ends facing to each other. In its relaxed state (Fig. 18), the clamping sleeve 10 can show a circular cross section, and in the pre-tensioned state (Fig. 19), and in the partially relaxed state (Fig. 20), an oval cross section. In this example, the cross section of the parts to be joined is oval.

Figures 22 - 25 correspond to the figures 12 - 15 and show a third connecting element according to the invention, featuring a clamping sleeve 10 with two constructive elements 2, 3 inserted; these constructive elements are oriented with their ends facing to each other. In its relaxed state (Fig. 22), the clamping sleeve 10 can show an oval cross section, in the pre-tensioned state (Fig. 23), it can show a deformed state as compared to the relaxed state, e.g. a circular or oval cross section, and in the partially relaxed state (Fig. 24), an oval cross section. In this example, the cross section of the constructive elements 2, 3 to be joined is circular.

Figures 26 - 29 correspond to the figures 12 - 15 and show a fourth connecting element according to the invention, featuring a clamping sleeve 10 with two construc-

tive elements 2, 3 to be connected, inserted; these constructive elements are arranged parallel to each other within a section of the clamping sleeve 10. In its relaxed state (Fig. 26), the clamping sleeve 10 can show a circular cross section, and in the pre-tensioned state (Fig. 27), and in the partially relaxed state (Fig. 28), an oval cross section. In this example, the cross section of the constructive elements 2, 3 to be joined is rectangular.

10

Figures 30 - 33 correspond to the figures 12 - 15 and show a fifth connecting element according to the invention, featuring a clamping sleeve 10 with three constructive elements 2, 3, 3a to be connected, inserted; these constructive elements are arranged parallel to each other within a section of the clamping sleeve 10. In its relaxed state (Fig. 30), the clamping sleeve 10 can show a circular or oval cross section, in the pre-tensioned state (Fig. 31) it can show a cross section deformed on three sides in radial direction, or a cross section flattened on three sides, respectively, and in the partially relaxed state (Fig. 32), a cross section arced on three sides. In this example, the cross section of the constructive elements 2, 3, 3a to be connected is circular.

20

List of reference signs

5	1	Compression spring
	2	First constructive element
	3	Second constructive element
	3a	Further constructive element
10	4	Tension spring
	5	Joint tube
	6	Section
	7	Leg spring
	8	First leg
	9	Second leg
	10	Clamping sleeve

11
 12
 13
 14
 15
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30
 31
 32
 33
 34
 35
 36
 37
 38
 39
 40
 41
 42
 43
 44
 45
 46
 47
 48
 49
 50
 51
 52
 53
 54
 55
 56
 57
 58
 59
 60
 61
 62
 63
 64
 65
 66
 67
 68
 69
 70
 71
 72
 73
 74
 75
 76
 77
 78
 79
 80
 81
 82
 83
 84
 85
 86
 87
 88
 89
 90
 91
 92
 93
 94
 95
 96
 97
 98
 99
 100
 101
 102
 103
 104
 105
 106
 107
 108
 109
 110
 111
 112
 113
 114
 115
 116
 117
 118
 119
 120
 121
 122
 123
 124
 125
 126
 127
 128
 129
 130
 131
 132
 133
 134
 135
 136
 137
 138
 139
 140
 141
 142
 143
 144
 145
 146
 147
 148
 149
 150
 151
 152
 153
 154
 155
 156
 157
 158
 159
 160
 161
 162
 163
 164
 165
 166
 167
 168
 169
 170
 171
 172
 173
 174
 175
 176
 177
 178
 179
 180
 181
 182
 183
 184
 185
 186
 187
 188
 189
 190
 191
 192
 193
 194
 195
 196
 197
 198
 199
 200
 201
 202
 203
 204
 205
 206
 207
 208
 209
 210
 211
 212
 213
 214
 215
 216
 217
 218
 219
 220
 221
 222
 223
 224
 225
 226
 227
 228
 229
 230
 231
 232
 233
 234
 235
 236
 237
 238
 239
 240
 241
 242
 243
 244
 245
 246
 247
 248
 249
 250
 251
 252
 253
 254
 255
 256
 257
 258
 259
 260
 261
 262
 263
 264
 265
 266
 267
 268
 269
 270
 271
 272
 273
 274
 275
 276
 277
 278
 279
 280
 281
 282
 283
 284
 285
 286
 287
 288
 289
 290
 291
 292
 293
 294
 295
 296
 297
 298
 299
 300
 301
 302
 303
 304
 305
 306
 307
 308
 309
 310
 311
 312
 313
 314
 315
 316
 317
 318
 319
 320
 321
 322
 323
 324
 325
 326
 327
 328
 329
 330
 331
 332
 333
 334
 335
 336
 337
 338
 339
 340
 341
 342
 343
 344
 345
 346
 347
 348
 349
 350
 351
 352
 353
 354
 355
 356
 357
 358
 359
 360
 361
 362
 363
 364
 365
 366
 367
 368
 369
 370
 371
 372
 373
 374
 375
 376
 377
 378
 379
 380
 381
 382
 383
 384
 385
 386
 387
 388
 389
 390
 391
 392
 393
 394
 395
 396
 397
 398
 399
 400
 401
 402
 403
 404
 405
 406
 407
 408
 409
 410
 411
 412
 413
 414
 415
 416
 417
 418
 419
 420
 421
 422
 423
 424
 425
 426
 427
 428
 429
 430
 431
 432
 433
 434
 435
 436
 437
 438
 439
 440
 441
 442
 443
 444
 445
 446
 447
 448
 449
 450
 451
 452
 453
 454
 455
 456
 457
 458
 459
 460
 461
 462
 463
 464
 465
 466
 467
 468
 469
 470
 471
 472
 473
 474
 475
 476
 477
 478
 479
 480
 481
 482
 483
 484
 485
 486
 487
 488
 489
 490
 491
 492
 493
 494
 495
 496
 497
 498
 499
 500
 501
 502
 503
 504
 505
 506
 507
 508
 509
 510
 511
 512
 513
 514
 515
 516
 517
 518
 519
 520
 521
 522
 523
 524
 525
 526
 527
 528
 529
 530
 531
 532
 533
 534
 535
 536
 537
 538
 539
 540
 541
 542
 543
 544
 545
 546
 547
 548
 549
 550
 551
 552
 553
 554
 555
 556
 557
 558
 559
 560
 561
 562
 563
 564
 565
 566
 567
 568
 569
 570
 571
 572
 573
 574
 575
 576
 577
 578
 579
 580
 581
 582
 583
 584
 585
 586
 587
 588
 589
 590
 591
 592
 593
 594
 595
 596
 597
 598
 599
 600
 601
 602
 603
 604
 605
 606
 607
 608
 609
 610
 611
 612
 613
 614
 615
 616
 617
 618
 619
 620
 621
 622
 623
 624
 625
 626
 627
 628
 629
 630
 631
 632
 633
 634
 635
 636
 637
 638
 639
 640
 641
 642
 643
 644
 645
 646
 647
 648
 649
 650
 651
 652
 653
 654
 655
 656
 657
 658
 659
 660
 661
 662
 663
 664
 665
 666
 667
 668
 669
 670
 671
 672
 673
 674
 675
 676
 677
 678
 679
 680
 681
 682
 683
 684
 685
 686
 687
 688
 689
 690
 691
 692
 693
 694
 695
 696
 697
 698
 699
 700
 701
 702
 703
 704
 705
 706
 707
 708
 709
 710
 711
 712
 713
 714
 715
 716
 717
 718
 719
 720
 721
 722
 723
 724
 725
 726
 727
 728
 729
 730
 731
 732
 733
 734
 735
 736
 737
 738
 739
 740
 741
 742
 743
 744
 745
 746
 747
 748
 749
 750
 751
 752
 753
 754
 755
 756
 757
 758
 759
 760
 761
 762
 763
 764
 765
 766
 767
 768
 769
 770
 771
 772
 773
 774
 775
 776
 777
 778
 779
 780
 781
 782
 783
 784
 785
 786
 787
 788
 789
 790
 791
 792
 793
 794
 795
 796
 797
 798
 799
 800
 801
 802
 803
 804
 805
 806
 807
 808
 809
 810
 811
 812
 813
 814
 815
 816
 817
 818
 819
 820
 821
 822
 823
 824
 825
 826
 827
 828
 829
 830
 831
 832
 833
 834
 835
 836
 837
 838
 839
 840
 841
 842
 843
 844
 845
 846
 847
 848
 849
 850
 851
 852
 853
 854
 855
 856
 857
 858
 859
 860
 861
 862
 863
 864
 865
 866
 867
 868
 869
 870
 871
 872
 873
 874
 875
 876
 877
 878
 879
 880
 881
 882
 883
 884
 885
 886
 887
 888
 889
 890
 891
 892
 893
 894
 895
 896
 897
 898
 899
 900
 901
 902
 903
 904
 905
 906
 907
 908
 909
 910
 911
 912
 913
 914
 915
 916
 917
 918
 919
 920
 921
 922
 923
 924
 925
 926
 927
 928
 929
 930
 931
 932
 933
 934
 935
 936
 937
 938
 939
 940
 941
 942
 943
 944
 945
 946
 947
 948
 949
 950
 951
 952
 953
 954
 955
 956
 957
 958
 959
 960
 961
 962
 963
 964
 965
 966
 967
 968
 969
 970
 971
 972
 973
 974
 975
 976
 977
 978
 979
 980
 981
 982
 983
 984
 985
 986
 987
 988
 989
 990
 991
 992
 993
 994
 995
 996
 997
 998
 999
 1000
 1001
 1002
 1003
 1004
 1005
 1006
 1007
 1008
 1009
 1010
 1011
 1012
 1013
 1014
 1015
 1016
 1017
 1018
 1019
 1020
 1021
 1022
 1023
 1024
 1025
 1026
 1027
 1028
 1029
 1030
 1031
 1032
 1033
 1034
 1035
 1036
 1037
 1038
 1039
 1040
 1041
 1042
 1043
 1044
 1045
 1046
 1047
 1048
 1049
 1050
 1051
 1052
 1053
 1054
 1055
 1056
 1057
 1058
 1059
 1060
 1061
 1062
 1063
 1064
 1065
 1066
 1067
 1068
 1069
 1070
 1071
 1072
 1073
 1074
 1075
 1076
 1077
 1078
 1079
 1080
 1081
 1082
 1083
 1084
 1085
 1086
 1087
 1088
 1089
 1090
 1091
 1092
 1093
 1094
 1095
 1096
 1097
 1098
 1099
 1100
 1101
 1102
 1103
 1104
 1105
 1106
 1107
 1108
 1109
 1110
 1111
 1112
 1113
 1114
 1115
 1116
 1117
 1118
 1119
 1120
 1121
 1122
 1123
 1124
 1125
 1126
 1127
 1128
 1129
 1130
 1131
 1132
 1133
 1134
 1135
 1136
 1137
 1138
 1139
 1140
 1141
 1142
 1143
 1144
 1145
 1146
 1147
 1148
 1149
 1150
 1151
 1152
 1153
 1154
 1155
 1156
 1157
 1158
 1159
 1160
 1161
 1162
 1163
 1164
 1165
 1166
 1167
 1168
 1169
 1170
 1171
 1172
 1173
 1174
 1175
 1176
 1177
 1178
 1179
 1180
 1181
 1182
 1183
 1184
 1185
 1186
 1187
 1188
 1189
 1190
 1191
 1192
 1193
 1194
 1195
 1196
 1197
 1198
 1199
 1200
 1201
 1202
 1203
 1204
 1205
 1206
 1207
 1208
 1209
 1210
 1211
 1212
 1213
 1214
 1215
 1216
 1217
 1218
 1219
 1220
 1221
 1222
 1223
 1224
 1225
 1226
 1227
 1228
 1229
 1230
 1231
 1232
 1233
 1234
 1235
 1236
 1237
 1238
 1239
 1240
 1241
 1242
 1243
 1244
 1245
 1246
 1247
 1248
 1249
 1250
 1251
 1252
 1253
 1254
 1255
 1256
 1257
 1258
 1259
 1260
 1261
 1262
 1263
 1264
 1265
 1266
 1267
 1268
 1269
 1270
 1271
 1272
 1273
 1274
 1275
 1276
 1277
 1278
 1279
 1280
 1281
 1282
 1283
 1284
 1285
 1286
 1287
 1288
 1289
 1290
 1291
 1292
 1293
 1294
 1295
 1296
 1297
 1298
 1299
 1300
 1301
 1302
 1303
 1304
 1305
 1306
 1307
 1308
 1309
 1310
 1311
 1312
 1313
 1314
 1315
 1316
 1317
 1318
 1319
 1320
 1321
 1322
 1323
 1324
 1325
 1326
 1327
 1328
 1329
 1330
 1331
 1332
 1333
 1334
 1335
 1336
 1337
 1338
 1339
 1340
 1341
 1342
 1343
 1344
 1345
 1346
 1347
 1348
 1349
 1350
 1351
 1352
 1353
 1354
 1355
 1356
 1357
 1358
 1359
 1360
 1361
 1362
 1363
 1364
 1365
 1366
 1367
 1368
 1369
 1370
 1371
 1372
 1373
 1374
 1375
 1376
 1377
 1378
 1379
 1380
 1381
 1382
 1383
 1384
 1385
 1386
 1387
 1388
 1389
 1390
 1391
 1392
 1393
 1394
 1395
 1396
 1397
 1398
 1399
 1400
 1401
 1402
 1403
 1404
 1405
 1406
 1407
 1408
 1409
 1410
 1411
 1412
 1413
 1414
 1415
 1416
 1417
 1418
 1419
 1420
 1421
 1422
 1423
 1424
 1425
 1426
 1427
 1428
 1429
 1430
 1431
 1432
 1433
 1434
 1435
 1436
 1437
 1438
 1439
 1440
 1441
 1442
 1443
 1444
 1445
 1446
 1447
 1448
 1449
 1450
 1451

ANT 34 ANT 7

09/145/28

16/97 Rec'd PCT/PTO 16 JAN 2001

PCT/DE99/01691

July 21, 2000

ERG 102/0Q/US

5

Claims

- 10 1. The invention relates to a connecting element for me-
chanically connecting constructive elements (2, 3),
comprising an elastically deformable tensioning ele-
ment which applies a holding force in its elastically
15 deformed state, onto at least one connected construc-
tive element (2), thus generating a nonpositive con-
nection of at least one constructive element (2) with
the tensioning element or with another constructive
element (3),

characterized in that

- 20 the tensioning element comprises a spring material
consisting of a superelastic shape memory alloy, in
particular a nickel-titanium alloy, elastically ex-
panded in the tensioning element.
- 25 2. Connecting element according to claim 1, **character-**
ized in that the holding force is generated by bend-
ing forces and/or shear forces originated by the ten-
sioning element during the elastic expansion of the
tensioning element.
- 30 3. Connecting element according to claim 1 or 2, **charac-**
terized in that the tensioning element is converted,
during assembly, from the austenitic state to the

tension-induced martensitic state, by elastic tensioning or expanding, respectively.

4. Connecting element according to one of the claims 1 to 3, **characterized in that** the holding force is a contact pressure generated by the elastic expansion of the tensioning element, applied to at least one connected constructive element, inserted into the tensioning element.
5. Connecting element according to one of claims 1 to 4, **characterized in that** the tensioning element comprises a helicoidal spring (1, 4, 7) which is inserted, in axial direction, into at least one constructive element (2) to be connected.
6. Connecting element according to claim 5, **characterized in that** the spring (1, 4, 7) is elastically deformed and pre-tensioned for inserting at least one constructive element (2), being partially relaxed for realizing the connection.
7. Connecting element according to claim 5, **characterized in that** the spring (1, 4, 7) is tensioned for generating the connection.
8. Connecting element according to claim 5 or 6, **characterized in that** the spring is a compression spring (1), which is compressed in axial direction for inserting at least one constructive element (2).
9. Connecting element according to claim 5 or 6, **characterized in that** the spring is a tension spring (4), which is stretched in axial direction for inserting at least one constructive element (2).

10. Connecting element according to claim 8 or 9, **characterized in that** during the insertion of at least one constructive element (2) the coil of the spring (1, 4) is turned open for increasing the diameter of the coil.
11. Connecting element according to one of claims 5 to 7, **characterized in that** the spring is a leg spring (7).
12. Connecting element according to claim 11, **characterized in that** the legs (8, 9) of the leg spring (7) are bent up during the insertion of at least one of the constructive elements (2) in order to increase the diameter of its windings and for pre-tensioning of the leg spring (7) against the direction of winding of the leg spring (7).
13. Connecting element according to claim 12, **characterized in that** the leg spring (7) is partially relaxed for generating the connection.
14. Connecting element according to claim 12, **characterized in that** the legs (8, 9) of the leg spring (7) are bent together in winding direction of the leg spring (7), exceeding the relaxed state, for a decrease of the diameter of its windings, to obtain the connection.
15. Connecting element according to claim 11, **characterized in that** the leg spring (7) is relaxed during the insertion of at least one of the constructive elements (2) to be connected, and that the legs (8, 9) of the leg spring (7) are bent together in the winding direction of the leg spring (7) for a decrease of

the diameter of its windings and for generating a tension in the leg spring (7), to obtain the connection.

- 5 16. Connecting element according to one of the claims 5 to 15, **characterized in that** a constructive element (2) to be connected, is inserted in the spring (1, 4, 7).
- 10 17. Connecting element according to one of the claims 5 to 15, **characterized in that** at least two constructive elements (2, 3) to be connected, are inserted in the spring (1, 4, 7).
- 15 18. Connecting element according to claim 17, **characterized in that** at least two constructive elements (2, 3) contact each other with their face ends, or are oriented with their ends facing to each other.
- 20 19. Connecting element according to claim 18, **characterized in that** connected constructive elements (2, 3) are surrounded, in the range of their contact point, by a joint element, in particular a joint tube (5) or various joint shells, transferring the holding force
- 25 of the spring (1, 4, 7) to the constructive elements (2, 3) to be connected.
20. Connecting element according to claim 17, **characterized in that** connected constructive elements (2, 3)
- 30 within the spring (1, 4, 7) are arranged parallel to each other in a section (6).
21. Connecting element according to one of claims 1 to 4, **characterized in that** the tensioning element comprises a clamping sleeve (10), into which at least
- 35

one constructive element (2) to be connected, is inserted in axial direction, whereby the clamping sleeve (10) is elastically deformed and pre-tensioned by compression, for inserting the at least one constructive element (2), and is partially relaxed for realizing the connection.

22. Connecting element according to claim 21, **characterized in that** the clamping sleeve (10) shows a circular cross section in the relaxed state, and shows an oval cross section in the pre-tensioned and in the partially relaxed state.
23. Connecting element according to claim 21, **characterized in that** the clamping sleeve (10) shows an oval cross section in the relaxed state, and shows a deformed state as compared to the relaxed state, e.g. a circular or oval cross section, in the pre-tensioned state, and shows an oval cross section in the partially relaxed state.
24. Connecting element according to claim 21, **characterized in that** the clamping sleeve (10) shows an oval or circular cross section in the relaxed state, and shows a cross section deformed on three sides in radial direction in the pre-tensioned state, and shows a cross section arced on three sides in the partially relaxed state.
25. Connecting element according to one of the claims 21 to 24, **characterized in that** two or more constructive elements (2, 3) to be connected, are inserted in the clamping sleeve (10), being arranged parallel to each other within a section (6) of the clamping sleeve (10).

26. Connecting element according to one of the claims 21 to 25, **characterized in that** two or more constructive elements (2, 3) to be connected, are inserted in the clamping sleeve (10), which contact each other with their face ends in the clamping sleeve (10), or which are oriented with their ends facing to each other.
27. Connecting element according to claim 11 and one of the claims 21 to 26, **characterized in that** at least one of the legs (8, 9) of the leg spring (7) is inserted in the clamping sleeve (10).
28. Connecting element according to claim 27, **characterized in that** both legs (8, 9) of the leg spring (7) are inserted in the clamping sleeve (10).
29. Connecting element according to one of the claims 27 to 28, **characterized in that** another constructive element (3) to be connected, is inserted in the clamping sleeve, which is arranged, within the clamping sleeve (10), besides at least one leg (8) of the leg spring (7).
30. Connecting element according to one of the claims 1 to 29, **characterized in that** at least one constructive element to be connected is inserted in the tensioning element, and a section (6) engaged with the tensioning element, of at least one of the constructive elements (2) to be connected, is friction-increased.

5

Summary

The invention relates to connecting elements for mechanically connecting constructive elements (2, 3). It is proposed to use an elastically deformable tensioning element (10), comprising a spring material consisting of a super-elastic shape memory alloy, in particular a nickel-titanium alloy, elastically expanded in the tensioning element (10).

15

(Fig. 14)

1/11

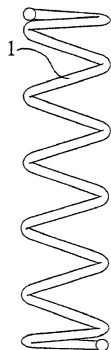


Fig. 1

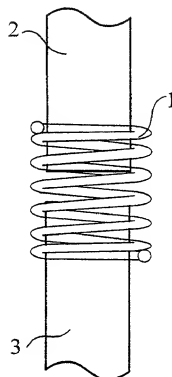


Fig. 2

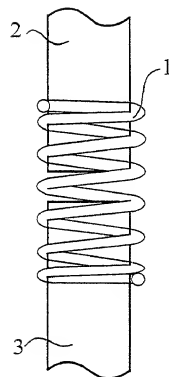


Fig. 3

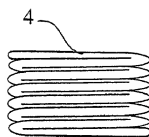


Fig. 4

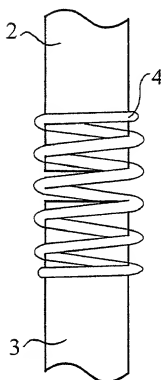


Fig. 5

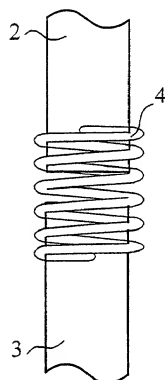


Fig. 6

2/11

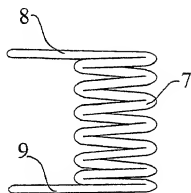


Fig. 8

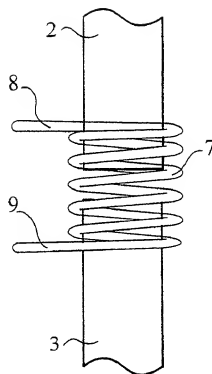


Fig. 9

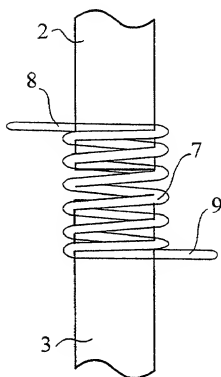


Fig. 10

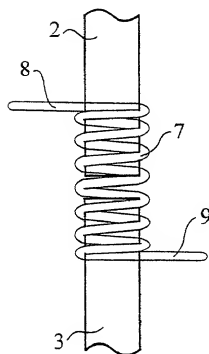


Fig. 11

3/11

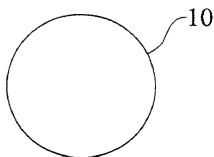


Fig. 12

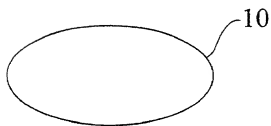


Fig. 13

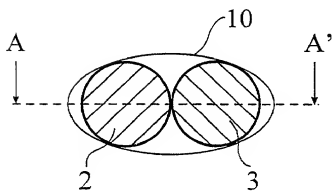


Fig. 14

4/11

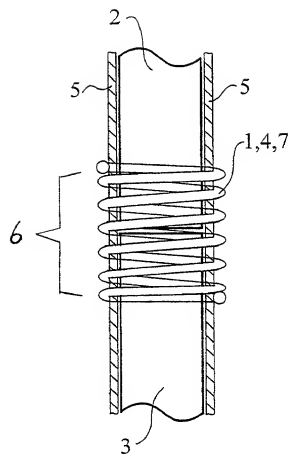


Fig. 7

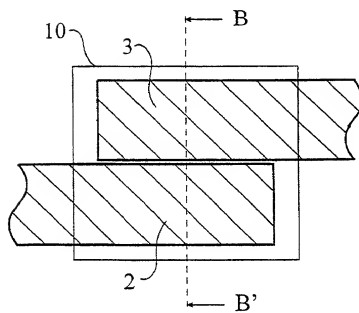


Fig. 15

5/11

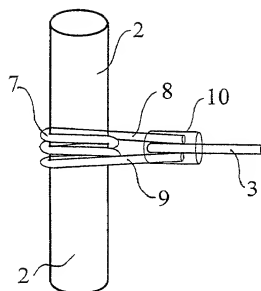


Fig. 16

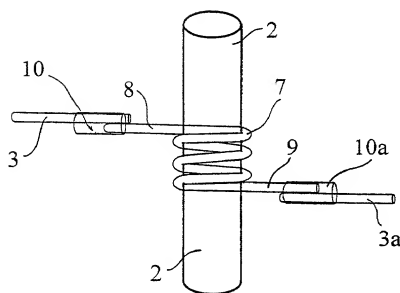


Fig. 17

6/11

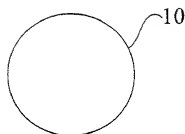


Fig. 18

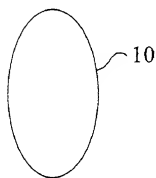


Fig. 19

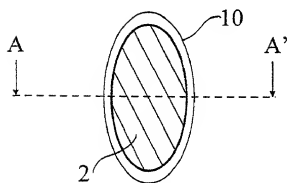


Fig. 20

09/745138 "011001
100110" 05254750

7/11



Fig. 22

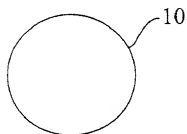


Fig. 23

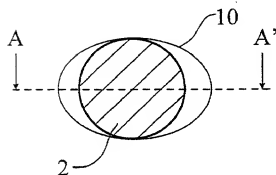


Fig. 24

09/743738-01691

8/11

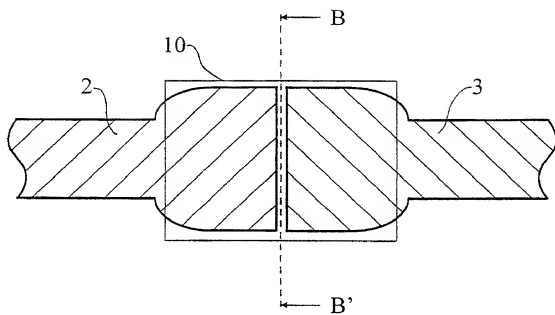


Fig. 21

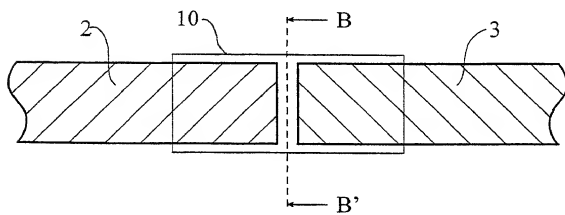


Fig. 25

9/11

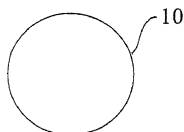


Fig. 26



Fig. 27

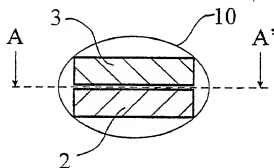


Fig. 28

10/11

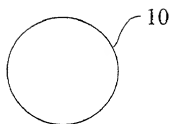


Fig. 30



Fig. 31

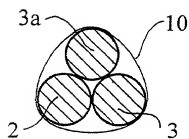


Fig. 32

11/11

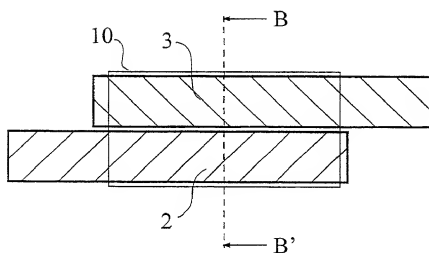


Fig. 29

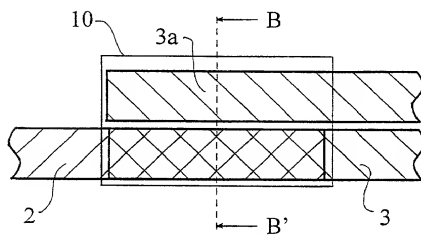


Fig. 33

Express Mail Label No. EL680595347US

Page 1 of 3

Docket No.
14989.260

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MECHANICAL CONNECTING ELEMENT

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____

and was amended on _____

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

198 34 305.1

Germany

July 30, 1998

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

PCT/DE99/01691 _____ (Application Serial No.)	June 5, 1999 _____ (Filing Date)	Pending _____ (Status) (patented, pending, abandoned)
_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)
_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

Ira J. Schaefer

Reg. No. 26,802

Send Correspondence to:

Ira J. Schaefer, Esq.
Chadbourne & Parke LLP
30 Rockefeller Plaza
New York, NY 10112

Direct Telephone Calls to: (name and telephone number)
212-408-1075

Full name of sole or first inventor <u>Hans Nusskern</u>	
Sole or first inventor's signature <u>Hans Nusskern</u>	Date <u>18.12.00</u>
Residence <u>Bechtbrunnenstraße 22, D-75181 Pforzheim-Huchenfeld, Germany</u> DEX	
Citizenship <u>German</u>	
Post Office Address <u>Same as above</u>	

Full name of second inventor, if any <u>Viktor Dahm</u>	
Second inventor's signature <u>Viktor Dahm</u>	Date <u>15.12.00</u>
Residence <u>Am Rieberg 11, D-75179 Pforzheim, Germany</u> DEX	
Citizenship <u>German</u>	
Post Office Address <u>Same as above</u>	